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ABSTRACT

This document accompanies Conceptual Learning and Development Assessment Series II: Cutting Tool, a test constructed to chart the conceptual development of individuals. As a technical manual, it contains information on the rationale, development, standardization, and reliability of the test, as well as essential information and statistical data for evaluating the test. This report is designed to be used by individuals who have a general knowledge of test construction and measurement principles and are aware of the limitations of test interpretations. The authors of this manual have attempted to take into account and satisfy the standards set forth by the American Psychological Association regarding educational and psychological tests. The test is based upon the Conceptual Learning and Development (CLD) Model, which suggest four successive levels of concept learning: (1) concrete--recognizing an object which has been encountered previously; (2) identity--recognizing a known object when it appears in a different spatial, time, or sensory perspective; (3) classificatory--generalizing that two items are alike in some way; and (4) formal--naming and defining the concept, listing its attributes, and judging the presence of such attributes in an object. (Author/GDC)

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Technical Report No. 435

TECHNICAL MANUAL FOR THE CONCEPTUAL LEARNING AND DEVELOPMENT ASSESSMENT SERIES II: CUTTING TOOL

by Geneva J. DiLuzio, Conrad G. Katzenmeyer, and Herbert J. Klausmeier

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

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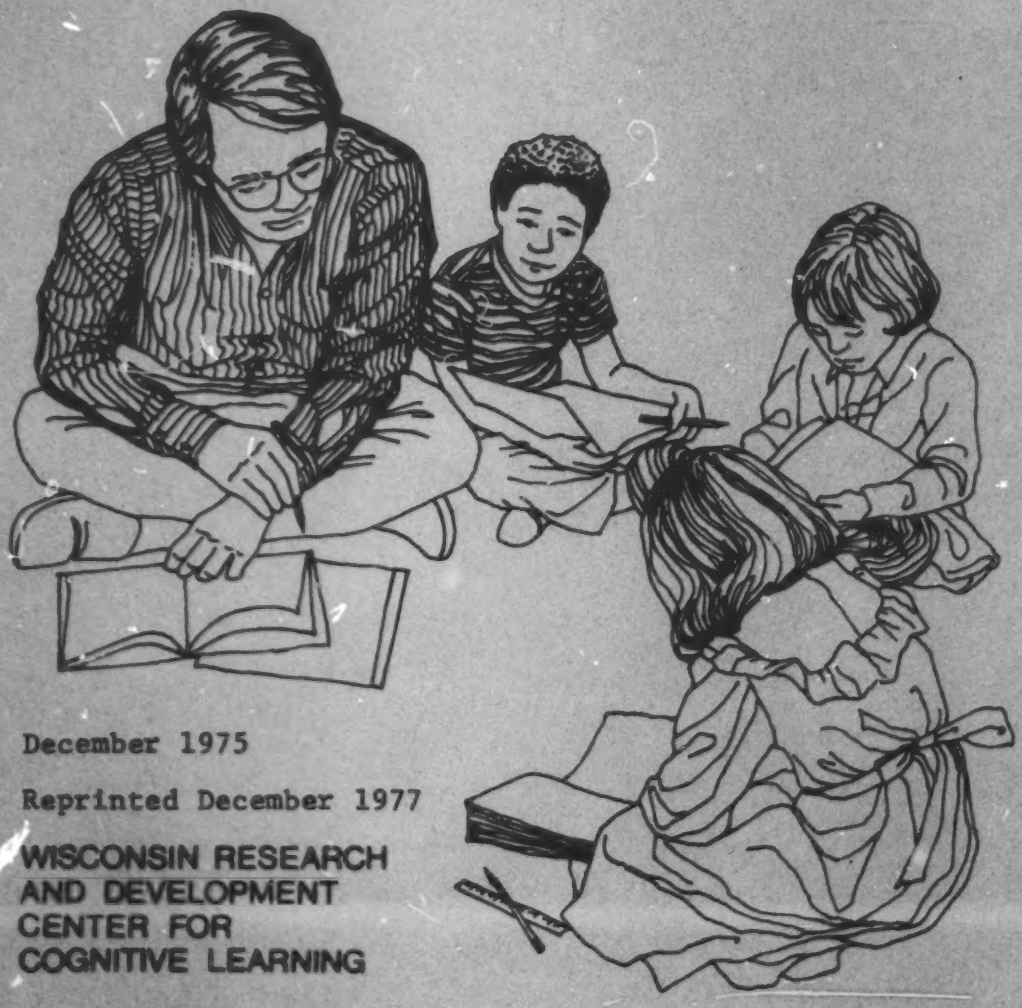

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Technical Report No. 435

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by

Geneva J. DiLuzio, Conrad G. Katzenmeyer,
and Herbert J. Klausmeier

Report from the
Technical Services Section

Wisconsin Research and Development
Center for Cognitive Learning
The University of Wisconsin
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ABSTRACT

This technical manual is one of three related publications to be used with the Conceptual Learning and Development Assessment Series II: Cutting Tool, a test constructed to chart the conceptual development of individuals. As a technical manual, it contains information on the rationale, development, standardization, and reliability of the test, as well as essential information and statistical data for evaluating the test.

This report is designed to be used by individuals who have a general knowledge of test construction and measurement principles and are aware of the limitations of test interpretations. The authors of this manual have attempted to take into account and satisfy the standards set forth by the American Psychological Association regarding educational and psychological tests.

An overview of the theoretical framework on which the test is based, a copy of the preliminary edition of the test battery, and directions for administration can be found in the Technical Report, Development of Conceptual Learning and Development Assessment Series II: Cutting Tool (Klausmeier, Bernard, Katzenmeyer, & Sipple, 1973. Reprinted December 1977).

The most complete source of information regarding the theoretical framework on which the test is based is in Conceptual Learning and Development: A Cognitive View (Klausmeier, Ghatala, & Frayer, 1974).

I

RATIONALE OF THE TEST

OVERVIEW OF THE CONCEPTUAL LEARNING AND DEVELOPMENT MODEL (CLD): THE BASES FOR TEST DEVELOPMENT

This technical manual provides information on the rationale, development, and statistical properties of the Conceptual Learning and Development Assessment Series II: Cutting Tool. The test battery is based upon the model of Conceptual Learning and Development (CLD model) proposed by Klausmeier (1971) and more fully described by Klausmeier, Ghatala, and Frayer (1974). The CLD model is the theoretical framework which provides the basis for determining children's level of attainment and use of a particular concept.

The Conceptual Learning and Development Series II: Cutting Tool was developed in the course of research on the CLD model for use in typical school settings. By providing the researcher with a measure of conceptual attainment, it permits the study of the relationships of level of conceptual attainment, concept usage, internal conditions of concept learning, and instructional conditions (Klausmeier, Ghatala, & Frayer, 1974). The instrument is unique in that it provides a standardized measure of the level of attainment of the concept cutting tool and the uses of that concept, and it can be group administered.

General Characteristics of the CLD Model

The general characteristics of the CLD model are summarized by Klausmeier, Bernard, Katzenmeyer, and Sipple (1973): It is an analytical, descriptive model. It defines four successive levels of concept attainment

and three types of concept usage. It specifies cognitive operations which are involved in learning concepts at each of the four levels. It relates internal and external conditions of learning to the specified levels.

Definition of Concepts

Klausmeier, Ghatala, and Frayer (1974) use the word concept to designate mental constructs of individuals as well as identifiable public entities which are part of the substance of various disciplines. Klausmeier, Davis, Ramsay, Fredrick, and Davies (1965) developed a definition of concept as an entity having a set of defining attributes, which is characteristic of concepts from a variety of disciplines. In addition, Klausmeier, Ghatala, and Frayer (1974) specified that most public concepts have eight attributes: learnability, usability, validity, generality, power, structure, instance numerousness, and instance perceptibility. Systematic analysis of a particular concept with regard to its various attributes is the method used to delineate the particular concept to be assessed by the battery and determine the format of the items used.

Structure of the Model

Levels of Concept Attainment. Four successive levels of concept attainment are specified by the model: concrete level, identity level, classificatory level, and formal level. Klausmeier, Bernard, Katzenmeyer, and Sipple (1973) describe the levels of attainment as follows:

> Attainment of a concept at the concrete level is inferred when the individual cognizes an object that he has experienced on a prior occasion. At this level, the object is experienced in exactly the same way on the second and later occasions. Attainment of a concept at the identity level is inferred when the individual cognizes an object as the same one previously encountered when observed from a different spatio-temporal perspective

> or sensed in a different modality. The attainment of a concept at the classificatory level is inferred when the individual treats at least two instances of the same set of things as equivalent. At this level the individual may be unable to name the attributes that are common to the instances. Attainment of a concept at the formal level is inferred when the individual can name the concept, discriminate and name the societally accepted defining attributes and values, and accurately evaluate instances as belonging or not belonging to the set in terms of the presence or absence of the defining attributes [p. 7].

The normative pattern postulated for individuals who are attaining a concept is to move successively from each level to the next higher level given the following conditions: First, the concept is of the kind for which there are either actual instances or representations of instances observable in the environment; and second, the individual has had experience with the instances beginning in early childhood (Klausmeier, Ghatala, & Frayer, 1974). It is acknowledged that some concepts are not attained at all four of the successive levels. This can occur either because of the nature of the concepts or because the learning experiences of the individual do not permit their acquisition.

Concept Utilization and Extension. Once a concept is attained at the classificatory or formal levels it may be used in four ways. The first use is an example of horizontal transfer, in which the individual can use the attained concept in recognizing newly encountered examples and nonexamples. The three other uses, cognizing supraordinate-subordinate relations, cognizing various other relations among concepts, and generalizing to problem-solving situations, are examples of vertical transfer, in which individuals extend their knowledge about an attained concept by using it. It is not implied that attainment of the concepts at the classificatory level or formal level will be followed by mastery of all the uses.

In cognizing supraordinate-subordinate relations, individuals can, after verbal instruction, place instances of hierarchically related concepts into proper groups and can justify their decisions based on the defining attributes of the group. At higher levels individuals are able to understand relationships described as the "whole is the sum of the parts" and "some but not all (Kofsky, 1966)." Understanding supraordinate-subordinate relationships increases the validity and usability of the individual's concepts (Klausmeier, Ghatala, & Frayer, 1974).

There are other statements of relations between or among concepts which involve causality, correlation, probability, or other valid relations. Being able to understand and use a valid relationship depends on knowledge of the concepts that are to be related. These types of relationships are different from relations among supraordinate and subordinate concepts (Klausmeier, Ghatala, & Frayer, 1974).

Problem solving is inferred in any situation where information about a concept or concepts is called into play and generalized to arrive at a solution to a particular problem. One example of concepts being used in problem solving is the application of familiar principles to new situations.

Other Characteristics of the Model

Information concerning the cognitive operations employed at each level of conceptual attainment and the internal and external conditions of learning necessary to concept attainment is presented in Conceptual Learning and Development: A Cognitive View (Klausmeier, Ghatala, & Frayer, 1974).

DESCRIPTION OF THE CONCEPTUAL LEARNING AND DEVELOPMENT ASSESSMENT SERIES II: CUTTING TOOL

Scope of the Test Battery

There are six subtests used to assess the level of conceptual attainment: concrete level, identity level, classificatory level, evaluating and defining, naming, and discriminating attributes. The last three of these subtests are used to assess attainment of the formal level. Three additional subtests are used to assess concept usage: supraordinate-subordinate relations, principles, and problem solving.

This battery may be used with children of ages 4-18. It was standardized on children at four grade levels: 1, 4, 7, and 10. The span of age represented in the standardization sample provides sufficient information to examine the usability of each subtest for children of various ages. Two forms of the test were developed, primary and intermediate. A simplified set of directions is used with the primary form, and certain subscales are administered in the primary form only (concrete and identity), while the uses are administered only in the intermediate form.

In the process of test development, some of the subtests constructed to measure desired outcomes were found to be too easy for children in some grades. Table 1 presents the set of subtests found to be most appropriate for administration at each of the four grade levels included in the standardization sample, as well as the number of items per subtest and average amount of time needed to administer each subtest for each form.

TABLE 1

APPROPRIATENESS, AVERAGE ADMINISTRATION TIME, AND ITEM CONTENT OF THE VARIOUS SUBTESTS OF THE CONCEPTUAL LEARNING AND DEVELOPMENT ASSESSMENT SERIES II: CUTTING TOOL FOR CHILDREN IN DIFFERENT GRADE GROUPS IN THE STANDARDIZATION SAMPLE

Subtest	Number of items				Average administration time in minutes			
	Primary form	Intermediate form			Primary form	Intermediate form		
	Grade 1	Grade 4	Grade 7	Grade 10	Grade 1	Grade 4	Grade 7	Grade 10
Concrete Level	8	NA	NA	NA	5	NA	NA	NA
Identity Level	8	NA	NA	NA				
Classificatory Level	8	8	8	NA	5	5	5	NA
Evaluating and Defining	7	7	7	7	5	4	4	4
Naming	5	5	5	5	4	3	3	3
Discriminating Attributes	6	6	6	6	3	3	3	3
Supraordinate-Subordinate Relationships	NA	10	10	10	NA	5	5	5
Principles	NA	10	10	10	NA	6	6	6
Problem Solving	NA	5	5	5	NA	4	4	4
Total Battery	42	51	51	43	22	30	30	25

NA = Not appropriate for these grade groups.

Concrete Level Subtest

This eight-item subtest is designed to assess whether a child has attained the concept cutting tool at the concrete level. A drawing of a cutting tool is presented to the child. After the child has looked at the drawing for a few seconds, the child is asked to turn to the next page of the answer booklet and find the drawing that looks exactly the same among four or seven tools. The correct choice has the same spatial orientation as on the preceding page. All instructions for this subtest are given orally and no written instructions appear.

The tools used vary systematically with respect to shape, size, shading of handle, cutting vs. non-cutting, and smooth-edged vs. tooth-edged. By varying the number of tools serving as alternatives and the number of attributes on which the incorrect alternatives differ from the correct choice, items of varying difficulty are obtained.

The placement of the correct choice among the distractors is varied randomly across the eight items. Seven or eight shapes, two sizes and three handle shadings are employed for each of the smooth-edged cutting tools, tooth-edged cutting tools and non-cutting tools. For the smooth-edged cutting tools, the shapes used are butcher knife, general purpose knife, hunting knife, paring knife, pocket knife, rasp, steak knife, and butter knife. Among the tooth-edged cutting tools, the shapes employed are bow saw, back saw, coping saw, hack saw, keyhole saw, rip saw, and tree saw. The shapes used for the non-cutting tools are bamboo rake, compass, hammer, mallet, clamp, ruler, screwdriver, and crescent wrench. Each figure may appear in one of two sizes, designated small and large. The lengths of the small figures are 2.4 to 2.6 centimeters and the lengths of the large figures are all 4.4 to 4.6 centimeters. The handle shadings are unshaded, grey, and black. A fourth designation of absent

is employed for the compass and ruler, as these tools do not have handles. Table 2 presents the number of distractors used in each item in the concrete level subtest, together with the attributes of the tools employed, and the number of attributes distinguishing the distractors from the target. The four-letter descriptors indicate the shape, type, size, and handle color of each tool, in that order. Type refers to a designation of both tool type (cutting vs. non-cutting) and edge type (smooth edge, tooth edge, or absent). A type designation of "K" indicates a smooth-edged cutting tool, "S" indicates a tooth-edged cutting tool, and "H" indicates a non-cutting hand tool. For the remaining attributes, these abbreviations are used:

Shapes for Type K Tools	Shapes for Type S Tools	Shapes for Type H Tools	Size	Handle Shadings
B Butcher Knife	A Bow Saw	B Bamboo Rake	D Small	A Handle Absent
G General Purpose Knife	B Back Saw	C Compass	L Large	B Black
H Hunting Knife	C Coping Saw	H Hammer		G Grey
K Paring Knife	H Hack Saw	M Mallet		U Clear
P Pocket Knife	K Keyhole Saw	P Clamp		
R Rasp	R Rip Saw	R Ruler		
S Steak Knife	T Tree Saw	S Screwdriver		
T Butter Knife		W Crescent Wrench		

Figures of the same description are used in the identity level, classificatory level and supraordinate-subordinate subtests with the addition of a few more shapes, and the same set of abbreviations will be used in referring to them.

TABLE 2

DESCRIPTION OF TOOLS EMPLOYED
IN THE CONCRETE LEVEL SUBTEST

Item	Number of Distractors	Number of Attributes on which Distractors Differ from Target	Correct Choice	Other Tools Serving as Alternatives
1	3	4 or 5	TKLU	MHLB, RHDA, SHLG
2	6	4	RKDB	HHLB, BHDU, WHDU, SHLB, CHDA, RHDA
3	3	3	SKDU	RSLU, BSDG, KSLU
4	3	2	GKDB	TKDG, HKLB, BKDU
5	3	4	RSDB	WHDU, HHLB, SHLB
6	6	4 or 5	HSLU	CHDA, PHDU, BHLB, MHLG, WHDU, SHDG
7	6	3	PKLG	ASDG, TSLU, CSLB, KSDG, BSLU, HSDG
8	6	1, 2 or 3	BKDU	HKLG, GKLB, PKDU, TKLU, KKLB, RKDU

Identity Level Subtest

This eight-item subtest is designed to assess whether a child has attained the concept cutting tool at the identity level. In this subtest, the task and stimulus materials are like those employed at the concrete level. However, the correct choice on the second page of each item is rotated so that it has a different spatial orientation than on the preceding page. The distractors presented with the correct choice also appear in various orientations so that the

correct choice is not conspicuous due to its irregular orientation. All instructions are given orally and no written instructions appear.

As in the concrete level subtest, the tools used vary systematically with respect to shape, size, shading of handle, cutting vs. non-cutting, and smooth-edged vs. tooth-edged. The eight items are of various difficulties due to differing numbers of distractors and degrees of similarity between the distractors and the correct choices. Both the pattern of the distractors and the figures used are identical to those provided in the concrete level subtest described above. The placement of the correct choice among the distractors is varied randomly across the eight items. The attributes of the tools appearing in each item of the identity level subtest are shown in Table 3 with the four-letter abbreviations given above. The approximate rotation of each figure in degrees counterclockwise from the horizontal (edge down for cutting tools), the number of distractors employed, and the number of attributes with respect to which they differ from the correct choice are also presented in Table 3. The target figure presented on the first page of each item is always a cutting tool in a horizontal position with the edge down.

Classificatory Level Subtest

This eight-item subtest is designed to assess whether a child has attained the concept cutting tool at the classificatory level. In the first four items, an example of a tool that is used to cut appears on the left side of the page, and the child is asked to mark the tool on the right side of the page which is also used to cut. In the remaining four items, the child is asked to mark the things that are used to cut, with no example provided. Items 1 and 2 each show four tools, including one cutting tool. In items 3 and 4, the

TABLE 3

DESCRIPTION OF TOOLS EMPLOYED IN THE IDENTITY LEVEL SUBTEST, AND THEIR APPROXIMATE DEGREES OF ROTATION

Item	Number of Distractors	Number of Attributes on Which Distractors Differ from Target	Correct Choice*	Other Tools Serving as Alternatives
1	3	4	RSDB 90°	WHDU 135°, HKLB 0°, SHLB 225°
2	6	4 or 5	HSLU 30°	CHDA 0°, PHDU 290°, BHLB 270°, MHLG 135°, WHDU 90°, SHDG 320°
3	6	3	PKLG 330°	ASDG 270°, TSLU 0°, CSLB 140°, KSDG 10°, BSLU 90°, HSDG 180°
4	6	1, 2 or 3	BKDU 225°	HKLG 180°, GKLB 90°, PKDU 0°, TKLU 90°, KKLB 225°, RKDU 135°
5	3	4 or 5	TKLU 135°	MHLB 90°, RHDA 45°, SHLG 320°
6	6	4	RKDB 90°	HHLB 330°, BHDU 210°, WHDU 0°, SHLB 320°, CHDA 270°, RHDA 30°
7	3	3	SKDU 45°	RSLU 210°, BSDG 120°, KSLU 0°
8	3	2	GKDB 320°	TKDG 270°, HKLB 90°, BKDU 225°

*On the first page of each item, the correct choice is shown in a position corresponding to 0° rotation. The rotation given above for each correct choice is for its representation among the other alternatives on the second page of the item.

child must select the cutting tool from among seven alternatives. Items 5 and 6 show five tools including two cutting tools; and items 7 and 8, ten tools, including four cutting tools. No item employs two tools of the same shape, size, shading of handle, or cutting edge. Cutting tools are randomly interspersed among the other tools. Instructions are read aloud, but written instructions also appear in the test booklet for each item.

The specifications of all the tools presented as examples and as alternatives are identical to those of the concrete level subtest, except that the paring knife (KK), steak knife (SK), bow saw (AS), coping saw (CS) and tree saw (TS) do not appear. Five new shapes are employed, two for the smooth-edged cutting tools and three for the non-cutting tools:

Additional Shapes for Type K Tools		Additional Shapes for Type H Tools	
A	Ax	A	Paint Brush
C	Kitchen Scissors	D	Double Box-end Wrench
		O	Broom

Table 4 presents the attributes of the tools employed in each item. The same four-letter abbreviations as above are employed, with the ax, kitchen scissors, paint brush, double box-end wrench and broom abbreviated as shown. All figures are presented horizontally, with the cutting edge, if any, down.

Formal Level Subtests

To determine if a concept has been attained at the formal level, three subtests are required: evaluating and defining, naming, and discriminating attributes.

TABLE 4

ATTRIBUTES OF TOOLS EMPLOYED
IN THE CLASSIFICATORY LEVEL SUBTEST

Item	Example Tool	Choices Presented: Cutting Tools	Choices Presented: Other Tools
1	TKLU	AKLU	MHLB RHDA SHLU
2	RSDB	BSDU	SHLB HHLB WHDU
3	RKDB	BKDG	CHDA HHLB WHDU RHDA BHDG PHDU
4	BSLU	KSLG	PHDU CHDA MHLG BHLB WHDU SHLG
5	*	KSDU HKLB	RHDA MHDB AHLU
6	*	HSLU PKLU	DHLY HHDB CHDA
7	*	BKDB HSLU KSLG GKLU	AHLU PHDU OHDU RHDA SHLU MHLB
8	*	HSLB HKLG CKDU AKLG	MHDB AHDU PHDU BHDU RHDA SHLG

*No example was given for items 5 through 8.

Evaluating and Defining Subtest. This seven-item multiple-choice subscale is designed to assess a child's ability to define the concept cutting tool and to evaluate instances as belonging or not belonging to the set "cutting tool" based on the presence or absence of defining attributes. The first five items present a drawing of a cutting tool on the left-hand side of the page, labeled "X." On the right-hand side of the page are three or four other drawings. The child is asked in what way "X" is different from all the other things. Five alternatives are presented for each item. The first four are statements of the form "X is used for _____"; "X is _____"; or "X has _____."

The sixth item in the subtest presents one smooth-edged and one tooth-edged cutting tool on the left side of the page, together labeled "Group X." Two drawings of non-cutting hand tools to the right of the page are labeled "Group Y." The correct alternative for the first six items is always one of the defining attributes, as presented in Table 5. The fifth alternative for each item is "I don't know." The seventh item in this subtest determines whether a child can recognize a definition of the concept cutting tool which is acceptable to content experts. The child is asked to choose the correct definition of the concept from among five alternatives, including "I don't know." Insturctions are read aloud. The test questions and alternatives appear in the test booklet and are also read aloud.

TABLE 5

DEFINING ATTRIBUTES BEING TESTED BY EACH OF THE FIRST SIX ITEMS OF THE EVALUATING AND DEFINING SUBTEST

Item	Defining Attribute
1	used for carrying out manual work
2	used to cut
3	sharp edge
4	hard edge
5	tough edge
6	blade that is either smooth or toothed

Naming Subtest. This five-item multiple-choice subtest is designed to assess a child's ability to label the societally-accepted attributes of the concept cutting tool. Two types of items are used in this subtest. Three items present a figure and ask the child to choose the answer which best describes or labels a particular attribute of the figure. The remaining two items each present two groups of figures and the child must choose the label which best fits all of the drawings in the first group of figures but does not fit all of the drawings in the second. All the items have five alternative choices, including "I don't know." Instructions are read aloud. The test question and alternatives appear in the test booklet and are also read aloud. The names of the attributes tested by each item appear in Table 6.

TABLE 6

NAMES OF ATTRIBUTES TESTED
BY EACH ITEM OF THE NAMING SUBTEST

Item	Attribute Label
1	tools
2	blade
3	cutting tools
4	toothed blade
5	smooth blade

Discriminating Attributes Subtest. This six-item subtest is designed to assess a child's ability to discriminate the societally-accepted attributes of the concept cutting tool. In each item, four figures are presented and

the child is asked to indicate the drawing which has some particular property. In each case the correct alternative is the only drawing which possesses some defining attribute of the concept cutting tool. The position of the correct alternative is varied randomly across the six items. The defining attributes assessed by each item are presented in Table 7. Instructions are read aloud and also appear in the test booklet with each item.

TABLE 7

DEFINING ATTRIBUTES BEING TESTED BY EACH ITEM
OF THE DISCRIMINATING ATTRIBUTES SUBTEST

Item	Attribute Distinguishing Correct Choice
1	used to carry out work of a mechanical kind
2	used to cut
3	has a sharp edge
4	has a hard edge
5	has a tough edge
6	has a toothed edge

Supraordinate-Subordinate Relations Subtest

This ten-item multiple-choice subtest is designed to assess a child's ability to relate the concept cutting tool to supraordinate, subordinate, and coordinate concepts. The child's understanding of four types of relations is assessed, with two or three items for each type. In each item six figures are presented and a question is asked concerning the relationship of various subsets. The description of the figure attributes employed is the same as for

the identity level subtest, except that only five shapes appear for the smooth-edged cutting tools and only three shapes each for the tooth-edged cutting tools and the non-cutting hand tools. Statements of the four relations tested are given in Table 8, as are lists of all the figures presented for each item, and lists of those figures which are examples of the supra-ordinate, subordinate, and/or coordinate classes to be related for each item. Examples of the tool classes referred to in the items are "[things that] have a blade that is smooth," "cutting tools," and "things above that have a black handle." The child must select the correct answer to the test question from among four alternatives, including "I don't know." Instructions are read aloud. The test questions and alternatives appear in the test booklet and are also read aloud.

Principles Subtest

This ten-item multiple-choice subtest is designed to assess whether a child understands various valid relationships among the properties of the concept cutting tool. These relationships are stated as five principles, each of which is tested both with and without illustration. In both cases an incomplete statement of a valid relationship between various properties of the concept is presented. The child must complete the statement by selecting the correct alternative from among four or five phrases, including "I don't know." Instructions are read aloud. The test questions and alternatives appear in the test booklet and are also read aloud. The principle tested in each item is listed in Table 9a, which also indicates whether or not an illustration is used with each item.

TABLE 8

RELATIONS TESTED AND CLASSES OF FIGURES EMPLOYED
IN THE SUPRAORDINATE-SUBORDINATE RELATIONS SUBTEST

Item	Type of relationship*	Figures presented	Type of first class(es) involved in statement of relation	Figures in first class(es)	Type of second class involved in statement of relation	Figures in second class
1	I	TKLB, BSLG, HSDU AKDU, RSDB, HKLG	Supraordinate	TKLB, BSLG, HSDU AKDU, RSDB, HKLG	Subordinate	TKLB, AKDU, HKLG
2	II	TKLB, BSLG, HSDU AKOU, RSDB, HKLB	Subordinate	TKLB, AKDU, HKLG	Supraordinate	TKLB, BSLG, HSDU ADKU, RSDB, HKLG
3	I	TKLB, BSLG, HSDU AKDU, RSDB, HKLG	Supraordinate	TKLB, BSLG, HSDU AKDU, RSDB, HKLG	Subordinate	BSLG, HSDU, RSDB
4	I	KKLB, HHLG, WHDU CKDU, MHDB, BSLG	Supraordinate	KKLB, HHLG, WHDU CKDU, MHDB, BSLG	Subordinate	KKLB, CKDU, BSLG
5	IV	TKLB, BSLG, HSDU AKDU, RSDB, HKLG	Coordinate	TKLB, BSLG, HKLG	Coordinate	TKLB, AKDU, HKLG
6	III	TKLB, BSLG, HSDU AKDU, RSDB, HKLG	Subordinate Subordinate	TKLB, AKDU, HKLG BSLG, HSDU, RSDB,	Supraordinate	TKLB, BSLG, HSDU AKDU, RSDB, HKLG
7	II	TKLB, BSLG, HSDU CKDU, RSDB, HKLG	Subordinate	BSLG, HSDU, RSDB	Supraordinate	TKLB, BSLG, HSDU CKDU, RSDB, HKLG
8	II	KKLB, HHLG, WHDU AKDU, MHDB, BSLG	Subordinate	KKLB, AKDU, BSLG	Supraordinate	KKLB, HHLG, WHDU AKDU, MHDB, BSLG
9	IV	TKLB, BSLG, HSDU AKDU, RSDB, HKLG	Coordinate	TKLB, RSDB	Coordinate	BSLG, HSDU, RSDB
10	III	KKLB, HHLG, WHDU CKDU, MHDB, BSLG	Subordinate Subordinate	KKLB, CKDU, BSLG HHLG, WHDU, MHDB	Supraordinate	KKLB, HHLG, WHOU CKDU, MHDB, BSLG

*The four relationships are as follows:

I. Some but not all members of a supraordinate class belong to a given subclass.
II. All members of a subclass are also members of a higher class.
III. The sum of the members of the subclasses equals the sum of the members of the supraordinate class.
IV. The members of one coordinate class are not members of another coordinate class.

Problem-Solving Subtest

This five-item multiple-choice subtest is designed to assess a child's ability to apply knowledge of the concept cutting tool in a particular problem-solving situation. For each item, drawings involving cutting tools are presented and the child is asked to solve a problem requiring the application of one of the five principles mentioned above. The child must select the correct alternative from five choices, including "I don't know." The principle required for each item is presented in Table 9b. Instructions are read aloud. Test questions and alternatives appear in the test booklet and are also read aloud.

Additional Information for the Concept "Cutting Tool"

Information regarding the concept analysis of cutting tool is available in the document by Klausmeier, Katzenmeyer, and Sipple (1973). This information includes definition of the concept; defining relevant and irrelevant attributes; examples and nonexamples of the concept used to assess the concrete, identity, classificatory, and/or formal levels and, in supraordinate-subordinate relations, principles, and/or problem solving; taxonomy of concepts related to cutting tool; and principles related to the concept. The source also gives a description of the content of each item in terms of the number and nature of the nonexamples used in the concrete and identity and classificatory subtests, descriptions of the relationships being assessed in the supraordinate-subordinate relations subtest, the attributes tested in the discriminating attributes subtest, principles being tested in the principles and problem-solving subtests, and labels tested in the naming subtest.

TABLE 9

PRINCIPLES ASSESSED AND USE OF ILLUSTRATIONS
IN THE PRINCIPLES AND PROBLEM-SOLVING SUBTESTS

a. Principles Subtest

Item	Principle*	Format
1	IV	with illustration
2	I	with illustration
3	V	with illustration
4	II	with illustration
5	III	with illustration
6	IV	without illustration
7	II	without illustration
8	I	without illustration
9	III	without illustration
10	V	without illustration

b. Problem Solving Subtest

Item	Principle*	Format
1	IV	with illustration
2	I	with illustration
3	III	with illustration
4	V	with illustration
5	II	with illustration

*The five principles are as follows:

I. A large cutting tool accomplishes a greater amount of cutting than a small cutting tool of the same kind.

II. A sharp cutting blade cuts more quickly than a dull blade.

III. A hard cutting blade remains sharper over a longer period of use than a soft blade.

IV. A tough cutting blade is less likely to break than a blade that is not tough.

V. The temperature at which blades are tempered determines the hardness of the blade.

DEVELOPMENT OF THE CONCEPTUAL LEARNING AND DEVELOPMENT ASSESSMENT SERIES II: CUTTING TOOL

Guidelines Used in Test Development

At the beginning of the test development activity the following guidelines were established for test construction and selection of a concept to be assessed. Test materials and instructions were to be appropriate for use with children from preschool age through high school and the test was to be group administered. It was necessary to choose a concept which could be presented in a paper-and-pencil format, which lent itself to definition in terms of defining attributes, and which was found in typical school curricula. The concept to be assessed had to be part of a taxonomy of related concepts, so that cognizing supraordinate and subordinate relationships could be tested; it also had to be usable in cognizing principles and in problem solving.

The concept cutting tool was chosen to satisfy these guidelines as an example of a general concept related more to science than to other curriculum areas. Three other batteries were constructed to assess concepts in other curriculum areas.

A second set of guidelines was used in developing the directions for test administration and item formats. The purpose of these guidelines was to ensure that valid responses could be obtained from children of all ages. First, "practice" questions would be offered. Second, specific repetitions of instructions or questions would be prescribed for use with younger children to ensure that they fully grasped the nature of the task. Third, all items would be read aloud by the test administrator since reading ability was not the specific measurement objective. Fourth, attractive item formats would be used

to engage the interest of the children. Fifth, all stimulus and response materials, such as in the classificatory items, would be arranged in a left-to-right flow. Sixth, items and pages would be designed so that children could easily keep their places.

Writing Items

Items were written according to specifications provided by the concept analyses and the guidelines reviewed earlier. Item writing was done by scholars at the Wisconsin Research and Development Center for Cognitive Learning who were knowledgeable in the area of conceptual learning and development and use of the CLD model. Guidance for item writing was provided by a measurement specialist who reviewed and edited all test items.

Review of Test Battery Content by Specialists

The test battery was reviewed for content accuracy by a content specialist in the area of engineering. Any inaccuracies in items were corrected at that time.

Tryout of Items

After the reviewing and editing were completed, the items and test directions were given an empirical tryout in winter of 1972 using a small group of students in each of grades K, 3, 6, and 9. Results of the tryout provided information regarding the clarity of instructions and illustrations, comprehensibility of test questions and alternatives, and amount of time needed to administer the battery. Finally, the results were examined to see if the

younger children were biased toward selecting particular answer positions in the test booklet. Children selected for participation in the tryout included an equal number of boys and girls in the categories of high, medium, and low scholastic achievers in order to ensure that information concerning clarity of directions and estimates of time needed to administer the test would be generalizable to the entire school populations. As a result of the tryout, items and test instructions were further revised and became the preliminary edition of the battery.

Preliminary Edition

The preliminary edition of the battery was used in spring of 1973 at two testing sites. Both sites were small Midwestern cities and all children tested were enrolled in public schools. The preliminary edition was administered to kindergartners, third, sixth, and ninth graders at both sites. Approximately 75 to 100 children were tested at each of the grade levels at each site. Test administrations at both sites were done by the same trained personnel from the Wisconsin Research and Development Center for Cognitive Learning.

The preliminary edition provided several types of information: analysis of the difficulty and discrimination indices of each item, reliability of the test, and the usability of the test with children in different grade groups.

Separate analyses were performed on the information from each of the two testing sites. Results from both sites indicated that item revisions were required to produce final test forms which would be suitable for the intended population of normal school children. It was concluded that the directions

were appropriate for group administration to children of various ability levels in a wide range of grade groups.

Development of Final Edition

Changes to the Preliminary Edition. At the completion of the analyses and review of the preliminary edition, a final edition of the battery was developed. The most significant differences between the two editions were the rewriting of several items and addition of several new items. Specifically, item format in the concrete and identity level subtests was modified and one new item was added to each subscale. In the classificatory subscale, examples of tools which seemed to be misleading or poorly depicted were replaced and three new items were added. The discriminating attributes subtest underwent extensive revisions, with three items being dropped and four new items written. Six evaluating items were constructed at this time, since no such items existed in the preliminary version. One item was dropped from the naming subscale. The wording of the five principles items not using illustrations and of the five problem-solving items was simplified. No new directions for administration of any additional items were required including the evaluating subscale, since these items were incorporated into an existing test booklet and were formulated similarly to the items just preceding them.

Production of Final Test Materials. A number of factors were considered in constructing the battery booklets to increase standardization of administration. The points incorporated in the standardized battery ensure that the children perform to their best advantage. First, instructions specific to each item are read aloud and also appear in the test booklet, reducing the influence of

reading ability on test scores. Second, the STOP instruction is prominently placed at the end of each item or bottom of each page as in the concrete and identity subtests. Third, readability of the print is enhanced by use of a primary typewriter and sufficient spacing between items to eliminate confusion.

The test is produced in four booklets and children mark their answers directly on the booklets.

Writing Test Administration Manuals. The general instructions were prepared to increase the uniformity with which the test is administered. Procedures and materials to be used in the testing program are clearly outlined in Development of Conceptual Learning and Development Series II: Cutting Tool (Klausmeier, Bernard, Katzenmeyer, & Sipple, 1973).

Instructions for administering specific subtests were developed on the basis of information gathered from the tryout of items on a small sample of children, criticisms and suggestions of test specialists, and suggestions of personnel who administered the test. The main criteria for these directions were clarity and usability. The test administration manual, found in the document Development of Conceptual Learning and Development Assessment Series II: Cutting Tool (Klausmeier, Bernard, Katzenmeyer, & Sipple, 1973), was provided for the preliminary edition, but it serves equally well for the final edition with appropriate substitutions in the text of the new items. By using a new copy of the test in conjunction with the manual, test administration may be standardized.

Computerized Analyses of Test Results. All information collected during the process of test development was prepared for electronic data processing. Personnel from the Wisconsin Research and Development Center for Cognitive Learning first transferred each child's responses from a test booklet to an answer sheet, and then keypunched these responses on computer cards. A computer program was used to score the data and generate records which were used in subsequent analyses.

Summary

This section of the technical manual has emphasized the steps taken at each point in the development of the test battery. From the formulation of the theoretical framework and rationale, to the item writing and editing, through the tryout and preliminary edition, steps were taken to develop a final version of the instrument that would measure the level of conceptual attainment and usage of the concept cutting tool.

II

STANDARDIZATION

The standardization of the Conceptual Learning and Development Assessment Series II: Cutting Tool was designed to provide information about the test and its appropriateness for use with populations of normal children across a span of several grade groups.

DESCRIPTION OF THE STANDARDIZATION SAMPLE

The standardization testing was conducted in spring of 1973 in Beloit, Wisconsin. Beloit's child and adult populations are representative of many small manufacturing-industrial communities in the Midwest. In 1972 the Beloit population was 35,729, including a black population of 2606 (7 percent of the total population), and 17,255 persons (48 percent of the total) under 25 years of age. The economic level of the community is somewhat higher than the average for Midwest industrial communities: The 1970 average income per household was $9460.00 and the median home value was $18,000.00 (Hooper & Klausmeier, 1973).

In the Beloit public school system there are 14 elementary schools, 3 junior high schools, and 1 senior high school. Total enrollment in these schools at the time of the standardization was approximately 10,000 students. Schools in which children were tested were selected in accord with the representative socioeconomic, ethnic, and general demographic classifications found in the city of Beloit (Hooper & Klausmeier, 1973).

Stratification variables used in selecting the population within each school were grade group and sex. Children from grades 1, 4, 7, and 10 were tested with an approximately equal number of boys and girls from each grade. The size, mean age, and range of age of the standardization sample for each grade group are presented in Table 10.

In the first year of the study, intact classrooms were randomly selected from among the schools chosen to represent the range of demographic characteristics discussed above. These children also served as the standardization sample for each of the other three batteries developed in the Conceptual Learning and Development Assessment Series.

TABLE 10

TOTAL NUMBER OF CHILDREN, MEAN AGE, AND AGE RANGE AT EACH GRADE GROUP IN THE STANDARDIZATION SAMPLE

Grade	Number		Mean Age (in years and months)	Age Range (in years and months)
1	Total	80	7 - 0	6 - 5 to 7 - 6
	Boys	40	7 - 0	6 - 5 to 7 - 6
	Girls	40	7 - 0	6 - 6 to 7 - 6
4	Total	92	10 - 0	9 - 5 to 10 - 10
	Boys	46	10 - 0	9 - 5 to 10 - 9
	Girls	46	10 - 0	9 - 5 to 10 - 10
7	Total	91	13 - 0	12 - 4 to 13 - 10
	Boys	44	13 - 0	12 - 5 to 13 - 10
	Girls	47	12 - 11	12 - 4 to 13 - 7
10	Total	86	15 - 11	15 - 4 to 16 - 9
	Boys	43	15 - 11	15 - 5 to 16 - 9
	Girls	43	15 - 10	15 - 4 to 16 - 7

These children are also the target population of a three-year longitudinal study to chart the course of conceptual development in children 4 to 18 years of age. In the first year of the longitudinal study, these children were tested using the preliminary edition of the test. However, the various subtests of this preliminary battery were modified for the final version of the test battery. Therefore, no practice effects arising from having tested the standardization sample a year earlier using the preliminary version of the battery were expected.

ADMINISTRATION OF THE TEST TO THE STANDARDIZATION SAMPLE

The battery was administered to the standardization sample according to the instructions specified in the Development of Conceptual Learning and Development Assessment Series II: Cutting Tool (Klausmeier, Bernard, Katzenmeyer, & Sipple, 1973). Tests were administered by trained personnel from the Wisconsin Research and Development Center for Cognitive Learning. For grades 4, 7, and 10 the battery was administered to classroom groups of 20 to 30 children, while for the first grade it was administered to smaller groups of five to seven children. The entire battery was read to all children regardless of grade level. Children marked their answers directly on the test pages; a separate answer sheet was not used.

MEANS AND STANDARD DEVIATIONS FROM THE STANDARDIZATION SAMPLE

Table 11 gives summary data for the raw scores resulting from the standardization testing. Means and standard deviations are given for each grade group on each subtest administered as well as on a combined formal levels score, a total levels score, and a total uses score. Appendix A contains the same summary data for each sex for each grade group.

As noted in Chapter 1, it is not necessary or desirable to administer all items or subtests to each grade group. Since it is assumed, based on information collected using the preliminary version of the battery, that children in the higher grade groups would respond correctly to all concrete level and identity level items, those subtests were administered to grade groups 1 and 4 only.[1] All other subtests were administered to each grade group.

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[1] Although summary data on the concrete level and identity level subtests are presented for the grade 4 group, examination of the data suggests that the subtests are too easy for use with grade 4 as well. (See Table 1, Chapter 1).

TABLE 11

MEANS AND STANDARD DEVIATIONS OF RAW SCORES ON EACH SUBTEST AND ON A COMBINED FORMAL SCORE, TOTAL LEVELS SCORE, AND TOTAL USES SCORE, BY GRADE GROUP FOR THE STANDARDIZATION SAMPLE

Subtest	Grade Group			
	1(n = 80)	4(n = 92)	7(n = 91)	10(n = 86)
Concrete (8 items)				
Mean	7.85	7.95	NA[a]	NA[a]
SD	.53	.27		
Identity (8 items)				
Mean	7.80	7.93	NA[a]	NA[a]
SD	.64	.25		
Classificatory (8 items)				
Mean	7.49	7.64	7.49	7.71
SD	.84	.93	1.21	.59
Evaluating & Defining (7 items)				
Mean	4.51	5.00	4.81	6.12
SD	1.89	1.70	1.93	1.30
Discriminating Attributes (6 items)				
Mean	4.61	4.73	4.86	5.29
SD	1.10	.93	1.10	.82
Naming (5 items)				
Mean	4.39	4.53	4.37	4.84
SD	.85	.88	1.10	.46
Combined Formal (18 items)				
Mean	13.51	14.26	14.04	16.24
SD	3.04	2.68	3.42	1.98
Total Levels (42 items)				
Mean	36.65	37.78	37.54	39.95
SD	3.47	3.28	3.96	2.25
Supraordinate-Subordinate Relationships (8 items)				
Mean	5.79	6.79	6.35	7.27
SD	1.65	1.25	1.66	1.00

TABLE 11 (cont.)

Subtest	Grade Group			
	1(n = 80)	4(n = 92)	7(n = 91)	10(n = 86)
Principles (10 items)				
Mean	5.14	5.39	5.76	7.70
SD	1.68	2.32	2.70	2.54
Problem Solving (5 items)				
Mean	3.08	3.64	3.14	3.84
SD	1.08	1.25	1.64	1.34
Total Uses (23 items)				
Mean	14.00	15.83	15.25	18.80
SD	3.07	3.68	5.20	4.10

[a]NA (Not Administered). On the basis of test results obtained with the preliminary edition of the battery, this subtest was judged to be too easy for use with this grade group. Thus, when the final edition was administered this subtest was not included for this grade group. All children in this grade group received full credit for this subtest in the computation of the total levels score.

III

STATISTICAL PROPERTIES

In reporting statistical data, three summary scores have been employed. The three subtests which are part of the formal level have been included in the combined formal level score which is equal to their sum. As much as the scores on these three subtests are always used in conjunction to assess attainment at the formal level, information on their individual properties is of lesser interest. A total levels score equal to the sum of the concrete level, identity level, classificatory level and combined formal scores and a total uses score equal to the sum of the supraordinate-subordinate relationships, principles, and problem-solving subtest scores are also presented. These two total scores provide summative indices of the two major aspects of the CLD model, namely conceptual attainment and conceptual utilization and extension.

RELIABILITY

Internal consistency for this battery was determined by the use of Hoyt's analysis of variance procedure, which is algebraically equivalent to Kuder Richardson's formula 20 and Cronbach's coefficient alpha. Internal consistency is of more interest than test-retest reliability in this battery, given that children's attainment of concepts is not expected to remain stable over time. Table 12 presents the Hoyt reliability coefficients and standard

errors of measurement of the individual subtests and of the combined formal level score, total levels score, and total uses score within each grade group and across the four grade groups.

Examination of Table 12 reveals that of the 34 Hoyt reliabilities reported, over half are .70 or better. Inspection of Table 11 containing means and standard deviations indicates that many of the lower reliabilities were obtained in cases where subtest means were over 90 percent of the total possible subtest score and standard deviations were very small. Means in this range and low standard deviations indicate an attenuation of the range of obtained scores which preclude higher Hoyt reliabilities being obtained. Although these subtests do not discriminate among the majority of the children in these grade groups, they provide valuable information in that they identify children who may not have attained the corresponding level of conceptual development or facility in concept utilization. Other low reliabilities were obtained in cases where the associated means and standard deviations were very low, again precluding obtainment of higher Hoyt reliabilities. These subtests will nonetheless identify children who have attained higher levels of conceptual development or greater facility in concept utilization.

ITEM DIFFICULTIES (PERCENT OF CORRECT RESPONSE)

Item difficulties in the form of percent of correct response to each item by grade group and across the grade groups are included in Appendix B. Point biserial correlations of each item with the total test score across the four grade groups are also presented.

TABLE 12

HOYT RELIABILITY COEFFICIENTS AND STANDARD ERRORS OF MEASUREMENT ON EACH SUBTEST AND ON A COMBINED FORMAL SCORE, TOTAL LEVELS SCORE, AND TOTAL USES SCORE, BY GRADE GROUP AND ACROSS THE FOUR GROUPS FOR THE STANDARDIZATION SAMPLE

Subtest	Grade Group				
	1(n = 80)	4(n = 92)	7(n = 91)	10(n = 86)	All Grades (n = 349)
Concrete (8 items)					
Reliability	.55	NR[a]	NA[b]	NA[b]	.51
SE_M	.33				.19
Identity (8 items)					
Reliability	.62	NR[a]	NA[b]	NA[b]	.53
SE_M	.37				.22
Classificatory (8 items)					
Reliability	.42	.70	.78	NR[a]	.63
SE_M	.60	.48	.52		.52
Combined Formal (18 items)					
Reliability	.73	.70	.82	.68	.77
SE_M	1.53	1.43	1.42	1.08	1.39
Total Levels (42 items)					
Reliability	.72	.75	.82	.69	.78
SE_M	1.83	1.63	1.66	1.24	1.62
Supraordinate-Subordinate					
Relationships (8 items)		.44	.67	.40	.58
SE_M	NR[c]	.88	.88	.72	.91
Principles (10 items)					
Reliability		.61	.71	.82	.73
SE_M	NR[c]	1.36	1.24	1.03	1.26
Problem Solving (5 items)					
Reliability		.47	.72	.64	.58
SE_M	NR[c]	.81	.77	.72	.80
Total Uses (23 items)					
Reliability		.71	.87	.85	.82
SE_M	NR[c]	1.94	1.83	1.58	1.87

TABLE 12 (cont.)

[a]NR (Not Reported). Upon examination of the results of the standardized testing, as indicated by the means and standard deviations reported in Table 11, this subtest was found to be too easy for use with this grade group (see Table 1, Chapter 1). Accordingly, reliability information would be meaningless and is not reported.

[b]NA (Not Administered). On the basis of test results obtained with the preliminary edition of the battery, this subtest was judged to be too easy for use with this grade group. Thus, when the final edition was administered this subtest was not included for this grade group. All children in this grade group received full credit for this subtest in the computation of the total levels statistic and in the computation of the all grades concrete and identity subtest statistics.

[c]NA (Not Reported). Upon examination of the results of the standardized testing, as indicated by the means and standard deviations reported in Table 11, this subtest was found to be too difficult for use with the grade group (see Table 1, Chapter 1). Accordingly, reliability information would be meaningless and is not reported.

The point biserial correlations were obtained by relating each of the items in the concrete level, identity level, classificatory level, and combined formal level subtests to the total levels score and each of the items in the supraordinate-subordinate relationships, principles, and problem solving subtests to the total uses score.

The fact that a greater percent of children answer a test item correctly in higher grade groups than in lower grade groups provides some evidence for the validity of the item. In grade groups 7 and 10 it is more likely that children have been exposed to widely differing instances of the concept cutting tool than it is in grade groups 1 and 4. Thus it is expected that they would perform better than the children in the lower grade groups. The item difficulties reported in Appendix B conform to this expected pattern in almost all cases, except for slight differences favoring grade 4 over grade 7. These anomalies might be accounted for by the lack of motivation of the children in grade group 7. A factor contributing to this lack of motivation was the time of test administration, quite late in the school year.

INTERCORRELATION OF THE TOTAL LEVELS SCORE WITH THE TOTAL USES SCORE

The intercorrelation of the total levels score with the total uses score is presented in Table 13 for each of the grade groups and across all the grade groups. The intercorrelation of the scores was not computable for grade group 1, since they did not receive any of the uses subtests. The range of correlations within each grade group is .49 to .74; the intercorrelation of the scores when all grade groups are combined is .62. These intercorrelations, although somewhat moderate, give support to the assumption that concept utilization is positively related to concept attainment.

TABLE 13

INTERCORRELATION OF THE TOTAL LEVELS SCORE AND THE TOTAL USES SCORE, BY GRADE GROUP AND ACROSS GRADE GROUPS FOR THE STANDARDIZATION SAMPLE

Grade Group	Correlation
1 (n = 80)	NA[a]
4 (n = 92)	.49
7 (n = 91)	.74
10 (n = 86)	.58
All Grade Groups (n = 349)	.62

[a]NA (Not Administered). On the basis of test results obtained with the preliminary edition of the battery, all of the uses subtests were judged to be too difficult for use with first-grade children. Thus, when the final edition was administered these subtests were not included for this grade group.

PATTERNS OF CONCEPT ATTAINMENT

One important use of the Conceptual Learning and Development Assessment Series II: Cutting Tool is in the placement of individual children on the continuum of conceptual development with respect to the concept cutting tool. For some applications it is desirable to reduce this information to the single datum of the level at which the child is performing. To facilitate this placement, a scoring scheme has been developed to indicate mastery vs. nonmastery of each of the concrete level, identity level, classificatory level, and combined formal subtests. All items are given equal weight, and full attainment of a level is indicated by a score greater than or equal to a predefined criterion score on the corresponding subtest. These criteria are presented in Table 14.

TABLE 14

NUMBER OF ITEMS AND CRITERIA DEFINING FULL ATTAINMENT FOR EACH CONCEPT LEVEL

Subtest	Number of Items	Criterion for Full Attainment
Concrete	8	7 correct
Identity	8	7 correct
Classificatory	8	7 correct
Combined Formal		
Evaluating and Defining	7	15 items correct or approximately 80% of combined formal items
Discriminating Attributes	6	
Naming	5	

Inasmuch as the test battery charts a child's passage through qualitatively different levels of conceptual attainment as additional cognitive operations are acquired, traditional indices of test performance suitable for use with norm-referenced measures are not entirely appropriate and may not adequately reflect the performance of the battery. Accordingly, in addition to Hoyt coefficients of reliability and traditional item statistics, a criterion-referenced scoring scheme is presented, and patterns of percent mastery across grade groups and across subtests assessing successive levels of conceptual attainment are also presented and discussed.

Table 15 presents the number and proportion of children within and across the four grade groups who mastered each of the four levels of concept attainment. According to the CLD model, the percentage of children passing each of the four successive levels should decrease within each grade group. Furthermore, for each of the four levels, the percentage of children passing should increase from the lower to the higher grade groups. Inspection of Table 15 reveals that only two exceptions to these predictions occurred, one of which was an increase of only one percent where a decrease was predicted, from concrete level to identity level for grade group 4. It will be recalled that the administration of the concrete and identity level subtests is not recommended at this grade level. The exception was a decrease of 3 percent where an increase was predicted, from grade group 4 to grade group 7 at the classificatory level. Again, lack of motivation in grade group 7 may account in part for this exception. Overall, the proportion of the 349 children who passed the various levels was .99 concrete level, .99 identity level, .91 classificatory level and .59 formal level. In the light of the theoretical predictions of the CLD model, these results support the validity of mastery decisions made on the basis of the test battery.

In addition to placing individual children at one of the four levels, these mastery decisions permit the examinations of validity of the test battery in the light of the hierarchical nature of the model. Inasmuch as attainment of each level requires the presence of conceptual abilities characteristic of the preceding levels, the model predicts that no child should master any one of the four levels subtests unless he also masters all preceding levels subtests. It is hypothesized that each successive

TABLE 15

NUMBER AND PROPORTION OF EACH GRADE GROUP THAT FULLY MASTERED EACH LEVEL OF ATTAINMENT

Grade	Concrete	Identity	Classificatory	Combined Formal
1st (n = 80)				
Number	79	79	71	35
Proportion	.99	.99	.89	.44
4th (n = 92)				
Number	91	92	85	45
Proportion	.99	1.00	.92	.49
7th (n = 91)				
Number	91	91	81	56
Proportion	1.00	1.00	.89	.62
10th (n = 86)				
Number	86	86	82	71
Proportion	1.00	1.00	.95	.83
All Grades (n = 349)				
Number	347	348	319	207
Proportion	.99	.99	.91	.59

level of attainment requires the use of one or more new cognitive operations. Therefore, each subtest would be more difficult than the previous one. A given pattern of attainment as indicated by the four mastery decisions derived from the levels subtests may be represented by a string of four letters, each either "P" or "F," denoting mastery (Passing) or nonmastery (Failing) of the corresponding subtest. The leftmost letter in such a string represents the concrete level subtest; the second, identity level; the third, classificatory; and the rightmost, combined formal. Thus, the pattern of attainment of a child who mastered the concrete level and identity level subtests and failed to master the classificatory level and combined formal subtests would be represented by the string "PPFF." On the basis of the hierarchical nature of the model, it is predicted that all children will attain one of the following 5 of the 16 possible patterns: FFFF, PFFF, PPFF, PPPF, and PPPP.

Table 16 shows the number and proportion of each grade group that attained the successive levels according to the five patterns and also the number and proportion of each grade group that were exceptions to the five patterns. Information regarding those who performed according to the predicted patterns is given in the top five rows; the exceptions are given in the lower rows. Of the 349 children, 338 or 97 percent performed according to the predicted patterns; only 3 percent or 11 children failed to conform to expected patterns.

The high percentage of children conforming to the predicted patterns supports the major proposition of the CLD model, that individuals attain concepts in a highly predictable pattern involving the four successive levels: concrete, identity, classificatory, and formal. The results also support the validity of the test battery as effectively charting the course of the development of the concept cutting tool.

TABLE 16

NUMBER AND PROPORTION OF FOUR GRADE GROUPS CONFORMING AND NOT CONFORMING TO PREDICTED SEQUENCE OF ATTAINMENT

Pass-Fail Sequence	1st (n = 80)	4th (n = 92)	7th (n = 91)	10th (n = 86)	All Grades (n = 349)
FFFF	0 .00	0 .00	0 .00	0 .00	0 .00
PFFF	0 .00	0 .00	0 .00	0 .00	0 .00
PPFF	5 .06	5 .05	8 .09	3 .03	21 .06
PPPF	39 .49	41 .45	27 .30	12 .14	119 .34
PPPP	31 .39	43 .47	54 .59	70 .81	198 .57
Subtotal Conforming	75 .94	89 .97	89 .98	85 .99	338 .97
FFFP	0 .00	0 .00	0 .00	0 .00	0 .00
FFPF	1 .01	0 .00	0 .00	0 .00	1 .00
FFPP	0 .00	0 .00	0 .00	0 .00	0 .00
FPFF	0 .00	0 .00	0 .00	0 .00	0 .00
FPFP	0 .00	0 .00	0 .00	0 .00	0 .00
FPPF	0 .00	1 .01	0 .00	0 .00	1 .00
FPPP	0 .00	0 .00	0 .00	0 .00	0 .00
PFFP	0 .00	0 .00	0 .00	0 .00	0 .00
PFPF	0 .00	0 .00	0 .00	0 .00	0 .00
PFPP	0 .00	0 .00	0 .00	0 .00	0 .00
PPFP	4 .05	2 .02	2 .02	1 .01	9 .03
Subtotal Not Conforming	5 .06	3 .03	2 .02	1 .01	11 .03

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APPENDIX A

DESCRIPTIVE SCALE STATISTICS FOR THE CUTTING TOOL BATTERY

TABLE A-1

MEANS AND STANDARD DEVIATIONS OF RAW SCORES ON EACH SUBTEST AND ON A COMBINED FORMAL SCORE, TOTAL LEVELS SCORE, AND TOTAL USES SCORE, BY GRADE GROUP, FOR BOYS IN THE STANDARDIZATION SAMPLE

Subtest	Grade Group			
	1(n = 40)	4(n = 47)	7(n = 44)	10(n = 43)
Concrete (8 items)				
Mean	7.90	7.91	NA[a]	NA[a]
SD	.30	.35		
Identity (8 items)				
Mean	7.88	7.94	NA[a]	NA[a]
SD	.33	.25		
Classificatory (8 items)				
Mean	7.53	7.66	7.45	7.53
SD	.82	.96	1.04	.74
Evaluating & Defining (7 items)				
Mean	4.70	5.17	4.39	5.95
SD	1.62	1.72	2.18	1.53
Discriminating Attributes (6 items)				
Mean	4.70	4.83	4.77	5.28
SD	.94	.92	1.22	.83
Naming (5 items)				
Mean	4.43	4.57	4.23	4.77
SD	.87	.74	1.29	.57
Combined Formal (18 items)				
Mean	13.83	14.57	13.39	16.00
SD	2.74	2.68	4.01	2.35
Total Levels (42 items)				
Mean	37.13	38.02	36.84	39.53
SD	2.81	3.28	4.38	2.77
Supraordinate-Subordinate Relationships (8 items)				
Mean	5.90	6.77	6.05	7.09
SD	1.74	1.25	1.79	1.21

TABLE A-1 (cont.)

Subtest	Grade Group			
	1(n = 40)	4(n = 47)	7(n = 44)	10(n = 43)
Principles (10 items)				
Mean	5.30	5.72	5.25	7.58
SD	1.70	2.30	2.86	2.86
Problem Solving (5 items)				
Mean	2.90	3.62	3.02	3.88
SD	.93	1.31	1.75	1.43
Total Uses (23 items)				
Mean	14.10	16.11	14.32	18.56
SD	3.10	3.74	5.60	4.71

[a]NA (Not Administered). On the basis of test results obtained with the preliminary edition of the battery, this subtest was judged to be too easy for use with this grade group. Thus, when the final edition was administered this subtest was not included for this grade group. All children in this grade group received full credit for this subtest in the computation of the total levels score.

TABLE A-2

MEANS AND STANDARD DEVIATIONS OF RAW SCORES ON EACH SUBTEST AND ON A COMBINED FORMAL SCORE, TOTAL LEVELS SCORE, AND TOTAL USES SCORE, BY GRADE GROUP, FOR GIRLS IN THE STANDARDIZATION SAMPLE

	Grade Group			
Subtest	1(n = 40)	4(n = 45)	7(n = 47)	10(n = 43)
Concrete (8 items)				
Mean	7.80	7.98		
SD	.69	.15	NA[a]	NA[a]
Identity (8 items)				
Mean	7.73	7.93		
SD	.85	.25	NA[a]	NA[a]
Classificatory (8 items)				
Mean	7.45	7.62	7.53	7.88
SD	.88	.91	1.35	.32
Evaluating & Defining (7 items)				
Mean	4.33	4.82	5.21	6.28
SD	2.13	1.67	1.59	1.01
Discriminating Attributes (6 items)				
Mean	4.53	4.62	4.94	5.30
SD	1.24	.94	.99	.83
Naming (5 items)				
Mean	4.35	4.49	4.51	4.91
SD	.83	1.01	.88	.29
Combined Formal (18 items)				
Mean	13.20	13.93	14.66	16.49
SD	3.31	2.66	2.66	1.52
Total Levels (42 items)				
Mean	36.18	37.54	38.19	40.37
SD	4.00	3.30	3.42	1.48
Supraordinate-Subordinate Relationships (8 items)				
Mean	5.68	6.82	6.64	7.44
SD	1.58	1.27	1.48	.70

TABLE A-2 (cont.)

Subtest	Grade Group 1(n = 40)	4(n = 45)	7(n = 47)	10(n = 43)
Principles (10 items)				
Mean	4.98	5.04	6.23	7.81
SD	1.67	2.32	2.48	2.20
Problem Solving (5 items)				
Mean	3.25	3.67	3.26	3.79
SD	1.19	1.19	1.55	1.25
Total Uses (23 items)				
Mean	13.90	15.53	16.13	19.05
SD	3.08	3.62	4.69	3.43

[a]NA (Not Administered). On the basis of test results obtained with the preliminary edition of the battery, this subtest was judged to be too easy for use with this grade group. Thus, when the final edition was administered this subtest was not included for this grade group. All children in this grade group received full credit for this subtest in the computation of the total levels score.

APPENDIX B

DESCRIPTIVE ITEM STATISTICS
FOR THE CUTTING TOOL BATTERY

TABLE B-1

DIFFICULTIES OF EACH ITEM IN THE TOTAL LEVELS SCORE BY GRADE GROUP, AND DIFFICULTIES AND POINT BISERIAL CORRELATIONS FOR THE SAME ITEMS COMBINING GRADE GROUPS FOR THE STANDARDIZATION SAMPLE

Item	1(n = 80) Difficulty	4(n = 92) Difficulty	7(n = 91) Difficulty	10(n = 86) Difficulty	Combined Grades (n = 349) Difficulty	r
Concrete Subtest						
1	1.00	NR[a]	NA[b]	NA[b]	1.00	.00
2	.99	NR[a]	NA[b]	NA[b]	1.00	.20
3	1.00	NR[a]	NA[b]	NA[b]	1.00	.00
4	.98	NR[a]	NA[b]	NA[b]	.99	.10
5	.98	NR[a]	NA[b]	NA[b]	.99	.10
6	1.00	NR[a]	NA[b]	NA[b]	1.00	.06
7	.95	NR[a]	NA[b]	NA[b]	.99	.20
8	.96	NR[a]	NA[b]	NA[b]	.99	.16
Identity Subtest						
9	1.00	NR[a]	NA[b]	NA[b]	1.00	.00
10	1.00	NR[a]	NA[b]	NA[b]	1.00	.02
11	.99	NR[a]	NA[b]	NA[b]	.99	.17
12	.95	NR[a]	NA[b]	NA[b]	.99	.20
13	1.00	NR[a]	NA[b]	NA[b]	1.00	.00
14	.99	NR[a]	NA[b]	NA[b]	1.00	.20
15	.95	NR[a]	NA[b]	NA[b]	.99	.11
16	.93	NR[a]	NA[b]	NA[b]	.97	.26
Classificatory Subtest						
17	1.00	.98	.99	NR[a]	.99	.27
18	1.00	.96	.99	NR[a]	.99	.28
19	.95	.97	.99	NR[a]	.97	.21
20	.99	.98	.99	NR[a]	.99	.21
21	.98	.99	.88	NR[a]	.95	.26
22	.84	.96	.90	NR[a]	.91	.30
23	.93	.91	.87	NR[a]	.90	.34
24	.81	.90	.89	NR[a]	.88	.32

TABLE B-1 (cont.)

Item	1(n = 80) Difficulty	4(n = 92) Difficulty	7(n = 91) Difficulty	10(n = 86) Difficulty	Combined Grades (n = 349) Difficulty	r
Combined Formal Subtest Evaluating & Defining						
25	.53	.65	.63	.87	.67	.40
26	.79	.89	.81	.94	.86	.51
27	.78	.83	.70	.84	.79	.55
28	.54	.77	.66	.87	.71	.51
29	.65	.63	.49	.79	.64	.48
30	.70	.67	.79	.90	.77	.56
31	.54	.55	.73	.91	.68	.53
Naming Subtest						
32	.98	.93	.86	.98	.93	.41
33	.79	.90	.85	.99	.88	.53
34	.84	.89	.86	.97	.89	.50
35	.93	.91	.96	.94	.93	.26
36	.86	.89	.86	.97	.89	.39
Discriminating Attributes Subtest						
37	1.00	.99	.97	.99	.99	.13
38	.98	1.00	.98	1.00	.99	.08
39	.78	.74	.86	.94	.83	.42
40	.33	.29	.37	.52	.38	.40
41	.71	.84	.74	.86	.79	.58
42	.83	.87	.95	.98	.91	.28

[a]NR (Not Reported). Upon examination of the results of the standardized testing, as indicated by the means and standard deviations reported in Table 11, this subtest was found to be inappropriate for use with this grade group (see Table 1, Chapter 1). Accordingly, item statistics would be meaningless and are not reported.

[b]NA (Not Administered). On the basis of test results obtained with the preliminary edition of the battery, this subtest was judged to be too easy for use with this grade group. Thus, when the final edition was administered this subtest was not included for this grade group. All children in this grade group received full credit for this subtest in the computation of the total levels statistic and in the computation of the combined grades concrete and identity subtest statistics.

TABLE B-2

DIFFICULTIES OF EACH ITEM IN THE TOTAL USES SCORE BY GRADE GROUP, AND DIFFICULTIES AND POINT BISERIAL CORRELATIONS FOR THE SAME ITEMS COMBINING GRADE GROUPS FOR THE STANDARDIZATION SAMPLE

Item	1(n = 80) Difficulty	4(n = 92) Difficulty	7(n = 91) Difficulty	10(n = 86) Difficulty	Combined Grades (n = 349) Difficulty	r
Supraordinate- Subordinate Relationships Subtest						
1	NR[a]	.96	.96	.97	.93	.28
2	NR[a]	.93	.91	.98	.91	.28
3	NR[a]	.96	.93	.97	.92	.25
4	NR[a]	.75	.65	.88	.72	.44
5	NR[a]	.85	.87	.94	.85	.34
6	NR[a]	.74	.67	.84	.75	.38
7	NR[a]	.86	.87	.88	.84	.44
8	NR[a]	.75	.49	.81	.66	.46
Principles Subtest						
9	NR[a]	.59	.52	.71	.60	.46
10	NR[a]	.63	.68	.84	.75	.34
11	NR[a]	.54	.48	.74	.51	.52
12	NR[a]	.66	.73	.85	.76	.48
13	NR[a]	.42	.37	.58	.43	.52
14	NR[a]	.62	.64	.86	.69	.52
15	NR[a]	.58	.79	.90	.73	.52
16	NR[a]	.62	.70	.79	.67	.46
17	NR[a]	.36	.40	.66	.45	.46
18	NR[a]	.37	.45	.77	.40	.50
Problem Solving Subtest						
19	NR[a]	.76	.70	.74	.74	.40
20	NR[a]	.86	.75	.86	.83	.45
21	NR[a]	.65	.49	.66	.62	.52
22	NR[a]	.66	.56	.73	.51	.47
23	NR[a]	.71	.64	.84	.73	.58

[a]NR (Not Reported). Upon examination of the results of the standardized testing, as indicated by the means and standard deviations reported in Table 11, this subtest was found to be inappropriate for use with this grade group (see Table 1, Chapter 1). Accordingly, item statistics would be meaningless and are not reported.

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